

Summary of Field Quality Data in D2L108

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Warm Measurements

- Warm measurements have been completed in all the nine D2 dipoles.
- Harmonics are measured with a 1 meter long mole at 10 axial locations in each aperture.
- Field angle is measured relative to gravity. Systematic error in calibration is removed by measuring field angles from both ends.
- Fiducials are surveyed on the test stand. The survey data are used to express field angles in the magnet frame.
- Integral transfer function is measured with a non-rotating, 10-meter long coil.
- All warm measurements are done before cold test.

D2L108 Vs. Mean and Standard Deviation

Integral Normal Harmonics (Warm) at 25 mm

	Left Aperture				Right Aperture			
	D2L Mean	D2L Std.Dev.	108(L)	No. of Sigma	D2L Mean	D2L Std.Dev.	108(R)	No. of Sigma
I.T.F. (T.m/kA)	5.9563	0.043%	5.9581	0.7	5.9563	0.043%	5.9587	0.9
Quadrupole*	-5.43	0.54	-5.43	0.0	5.30	0.54	5.21	-0.2
Sextupole	-3.40	1.37	-2.78	0.4	-3.40	1.37	-1.55	1.3
Octupole	0.09	0.15	0.14	0.4	0.09	0.15	0.31	1.5
Decapole	0.57	0.43	0.67	0.2	0.57	0.43	0.51	-0.1
12-pole	-0.02	0.05	0.02	0.7	-0.02	0.05	-0.04	-0.4
14-pole	0.05	0.10	0.01	-0.4	0.05	0.10	0.01	-0.4
16-pole	0.00	0.02	0.02	0.8	0.00	0.02	0.01	0.3
18-pole	-0.14	0.03	-0.18	-1.3	-0.14	0.03	-0.12	0.4
20-pole	0.00	0.01	0.00	0.2	0.00	0.01	-0.01	-0.6
22-pole	-0.64	0.02	-0.67	-1.9	-0.64	0.02	-0.67	-1.9
24-pole	0.00	0.01	0.00	-0.6	0.00	0.01	0.00	-0.2
26-pole	-0.26	0.01	-0.26	0.5	-0.26	0.01	-0.27	-0.4

* Mean values of the normal quadrupole term are treated as aperture dependent.
 All other terms are considered aperture independent.

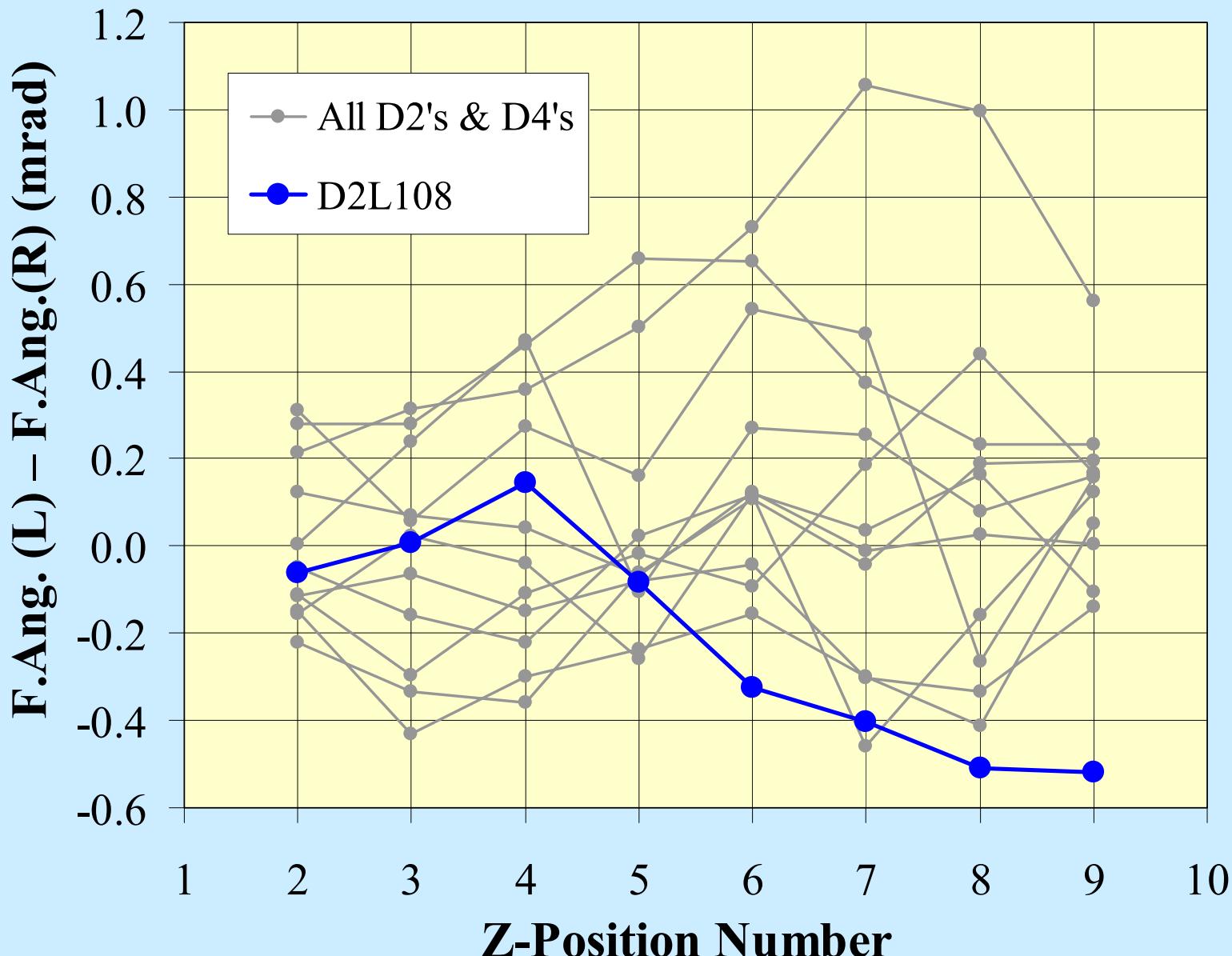
D2L108 Vs. Mean and Standard Deviation

Integral Skew Harmonics (Warm) at 25 mm

	D2L Mean	D2L Std.Dev.	108(L)	No. of Sigma	108(R)	No. of Sigma
Fld. Angle (mrad)	-0.60	0.25	-0.47	0.5	-0.25	1.4
Quadrupole	-0.09	1.88	1.22	0.7	-2.76	-1.4
Sextupole	-1.11	0.34	-1.10	0.1	-1.47	-1.0
Octupole	0.14	0.64	0.26	0.2	-0.97	-1.7
Decapole	0.16	0.10	0.13	-0.3	0.08	-0.7
12-pole	0.04	0.18	0.12	0.5	-0.18	-1.2
14-pole	-0.09	0.03	-0.07	0.6	-0.09	-0.1
16-pole	0.01	0.05	-0.03	-0.8	0.01	-0.1
18-pole	0.02	0.01	0.02	0.0	0.02	-0.3
20-pole	0.02	0.02	0.00	-1.5	0.01	-0.8
22-pole	0.00	0.01	-0.01	-0.9	-0.01	-1.5
24-pole	0.01	0.01	0.02	1.0	0.01	0.1
26-pole	0.01	0.01	0.01	0.6	0.00	-0.5

Field angles are as measured on test stand wrt gravity

Field Angle Alignment in D2/D4 Dipoles



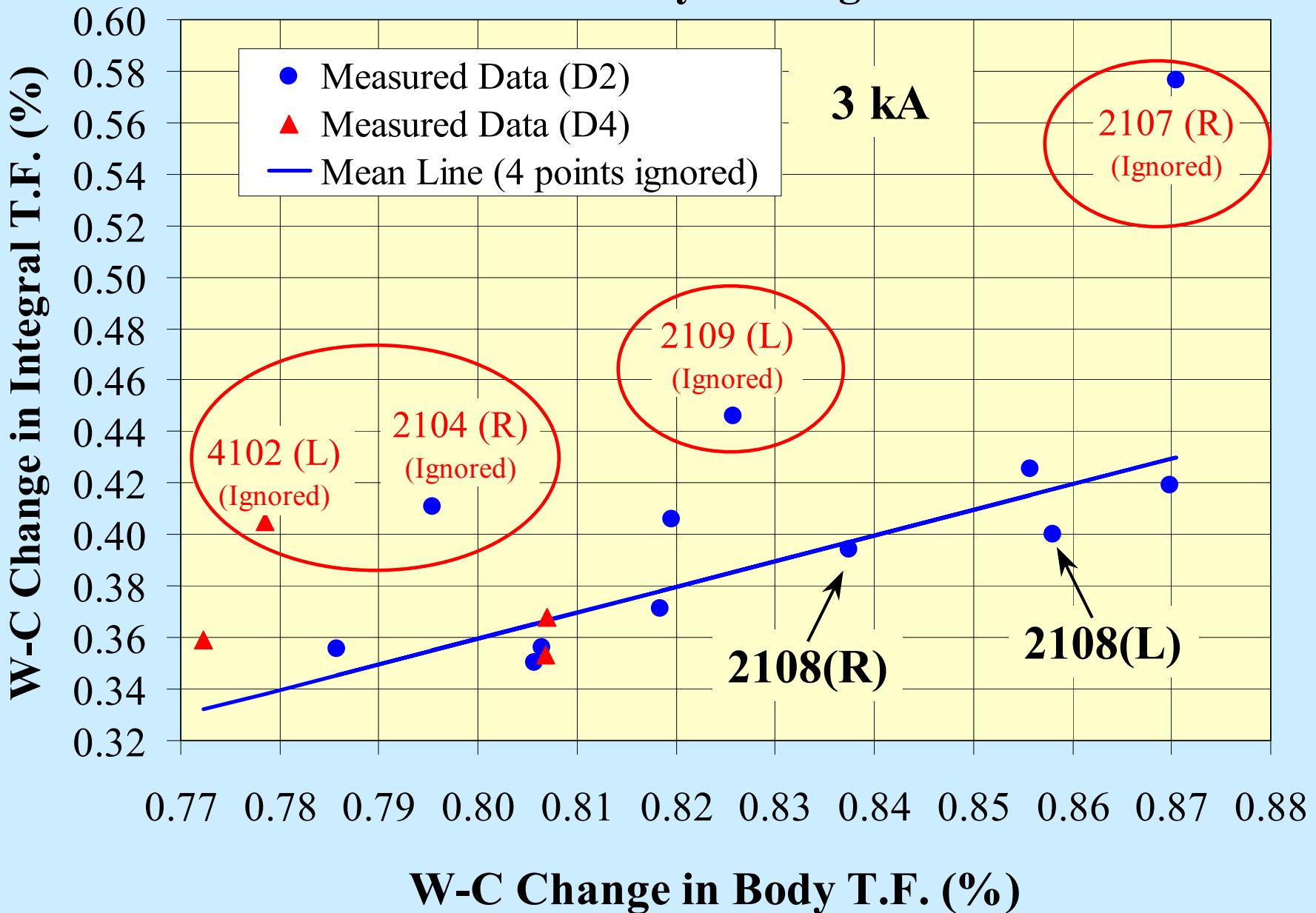
Cold Measurements

- Only a minimal set of measurements was done in D2L108.
- Minimal set consists of a sparse excitation curve at each of the 10 axial positions, in each aperture.
- The 19 currents in the sparse loop cover 200A to 6400A, and are carefully chosen to catch all the “features” of a full excitation curve.
- The integral T.F. is obtained from Z-scan only, and can have random errors of up to $\sim 0.1\%$.
- Down ramp measurements are done at only one position in each aperture.
- No dynamic measurements were made in D2L108.

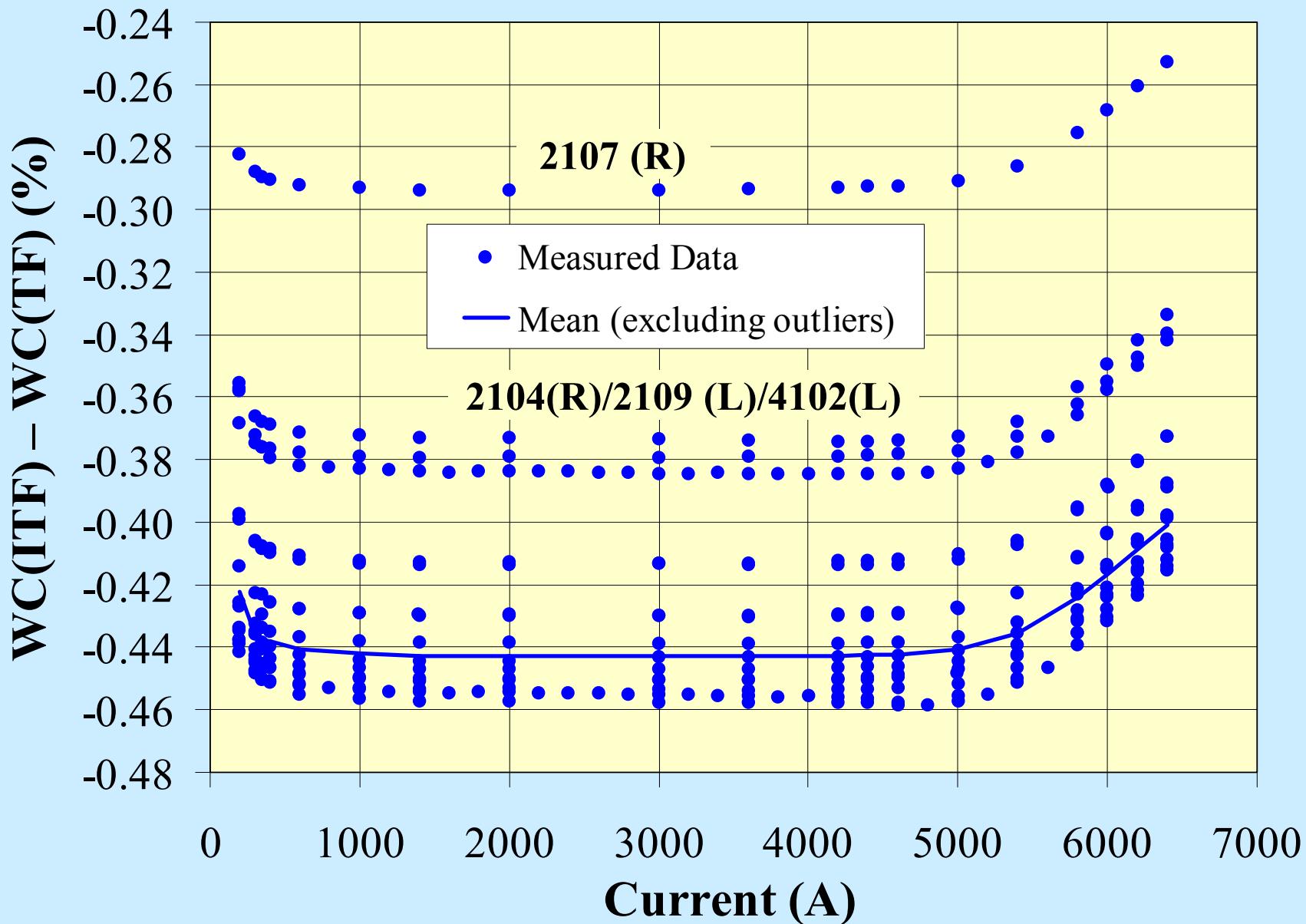
Field Angle Changes on Cool Down in D2L108



Correlation between Body & Integ. T.F. Warm-Cold



Body TF and ITF W-C Offset differences as a function of Current



Comparison of Field Quality in D2L108 with the Expected Ver 1.0 Tables

Expected Ver 1.0 Table (25 mm)

Integral Harmonics at 315A (0.2 Tesla)

n	$\langle bn \rangle$	$\Delta(bn)$	$\sigma(bn)$	$\langle an \rangle$	$\Delta(an)$	$\sigma(an)$
2	0.08	0.77	0.28	-0.12	3.68	1.53
3	-9.92	5.52	1.95	-1.10	0.49	0.17
4	-0.05	0.20	0.08	0.13	1.15	0.42
5	0.64	0.83	0.40	0.18	0.16	0.06
6	-0.01	0.08	0.03	-0.03	0.54	0.15
7	-0.26	0.21	0.10	-0.09	0.07	0.02
8	-0.03	0.03	0.01	-0.01	0.15	0.05
9	0.14	0.13	0.04	0.02	0.03	0.01
10	0.03	0.05	0.02	0.02	0.05	0.02
11	-0.66	0.04	0.02	-0.01	0.02	0.01

Measured Data in D2L108 & Ver 1.0 Comparison

Integral; 0.2 Tesla (interpolated) at 25 mm radius

n	$bn(L)$	$bn(R)$	$an(L)$	$an(R)$	n	$bn(L)$	$bn(R)$	$an(L)$	$an(R)$
2	5.15	-5.63	0.64	-2.08	2	??	??	OK	OK
3	-14.66	-14.23	-1.19	-1.41	3	OK	OK	OK	OK
4	0.49	-0.29	0.06	-1.07	4	??	OK	OK	OK
5	0.92	0.80	0.18	0.08	5	OK	OK	OK	OK
6	0.11	-0.09	0.03	-0.19	6	??	OK	OK	OK
7	-0.37	-0.39	-0.14	-0.12	7	OK	OK	OK	OK
8	0.01	-0.04	-0.07	0.00	8	OK	OK	OK	OK
9	-0.01	0.07	0.05	0.02	9	OK	OK	OK	OK
10	-0.02	-0.01	0.00	0.05	10	OK	OK	OK	OK
11	-0.83	-0.82	0.02	-0.01	11	??	??	??	OK

Note: Large b2 at low fields was not foreseen in Ver 1.0 tables

Expected Ver 1.0 Table (25 mm)

Integral Harmonics at 3.8 Tesla (6000 A)

n	$\langle bn \rangle$	$\Delta(bn)$	$\sigma(bn)$	$\langle an \rangle$	$\Delta(an)$	$\sigma(an)$
2	-0.07	0.79	0.28	0.53	3.71	1.51
3	1.99	3.57	1.70	-1.07	0.55	0.18
4	-0.21	0.21	0.08	0.05	1.08	0.41
5	0.04	0.80	0.39	0.19	0.17	0.06
6	-0.05	0.10	0.04	0.00	0.55	0.16
7	0.06	0.19	0.10	-0.10	0.06	0.02
8	-0.01	0.03	0.01	-0.01	0.15	0.05
9	0.00	0.12	0.04	0.01	0.03	0.01
10	0.03	0.05	0.02	0.03	0.04	0.02
11	-0.56	0.04	0.02	-0.01	0.01	0.01

Measured Data in D2L108 & Ver 1.0 Comparison

Integral; 3.8 Tesla (6000 A) at 25 mm radius

n	$bn(L)$	$bn(R)$	$an(L)$	$an(R)$	n	$bn(L)$	$bn(R)$	$an(L)$	$an(R)$
2	-0.08	-0.15	1.05	-2.65	2	OK	OK	OK	OK
3	-0.31	0.75	-1.06	-1.37	3	OK	OK	OK	OK
4	0.35	-0.23	0.12	-0.93	4	??	OK	OK	OK
5	0.24	0.10	0.18	0.12	5	OK	OK	OK	OK
6	0.16	-0.13	0.09	-0.19	6	??	OK	OK	OK
7	0.13	0.13	-0.09	-0.11	7	OK	OK	OK	OK
8	0.02	-0.04	-0.06	-0.01	8	OK	OK	OK	OK
9	-0.21	-0.14	0.03	0.02	9	??	OK	OK	OK
10	-0.01	-0.01	0.02	0.04	10	OK	OK	OK	OK
11	-0.67	-0.66	0.00	0.00	11	??	??	OK	OK

OK=Value between (mean- $\Delta-\sigma$) & (mean+ $\Delta+\sigma$)

Comparison of Field Quality in D2L108 with the Expected Ver 2.0 Tables

Expected Ver 2.0 Table (at 25 mm radius)

Integral Harmonics at 315A (0.2 Tesla)

n	$\langle bn \rangle(L)$	$\langle bn \rangle(R)$	$\Delta(bn)$	$\sigma(bn)$	$\langle an \rangle$	$\Delta(an)$	$\sigma(an)$
2	4.08	-5.07	1.97	0.63	-0.03	5.99	1.56
3	-22.28	-22.28	1.87	1.50	-0.72	0.74	0.44
4	-0.08	-0.56	0.36	0.20	-0.84	0.65	0.41
5	1.17	1.17	1.20	0.85	0.21	0.25	0.18
6	0.04	-0.16	0.20	0.12	0.10	0.67	0.39
7	-0.40	-0.40	0.16	0.11	-0.13	0.08	0.05
8	-0.03	-0.03	0.04	0.03	-0.01	0.27	0.17
9	0.16	0.16	0.15	0.10	0.03	0.03	0.02
10	-0.03	-0.03	0.08	0.04	0.02	0.08	0.05
11	-0.77	-0.77	0.03	0.02	0.02	0.02	0.01

Measured Data in D2L108

Integral; 0.2 Tesla (interpolated) at 25 mm radius

n	$bn(L)$	$bn(R)$	$an(L)$	$an(R)$	n	$bn(L)$	$bn(R)$	$an(L)$	$an(R)$
2	5.15	-5.63	0.64	-2.08	2	OK	OK	OK	OK
3	-14.66	-14.23	-1.19	-1.41	3	??	??	OK	OK
4	0.49	-0.29	0.06	-1.07	4	??	OK	OK	OK
5	0.92	0.80	0.18	0.08	5	OK	OK	OK	OK
6	0.11	-0.09	0.03	-0.19	6	OK	OK	OK	OK
7	-0.37	-0.39	-0.14	-0.12	7	OK	OK	OK	OK
8	0.01	-0.04	-0.07	0.00	8	OK	OK	OK	OK
9	-0.01	0.07	0.05	0.02	9	OK	OK	OK	OK
10	-0.02	-0.01	0.00	0.05	10	OK	OK	OK	OK
11	-0.83	-0.82	0.02	-0.01	11	??	OK	OK	OK

Expected Ver 2.0 Table (at 25 mm radius)

Integral Harmonics at 3.8 Tesla (6000 A)

n	$\langle bn \rangle(L)$	$\langle bn \rangle(R)$	$\Delta(bn)$	$\sigma(bn)$	$\langle an \rangle$	$\Delta(an)$	$\sigma(an)$
2	-0.50	-0.77	1.02	0.32	-0.67	5.94	1.55
3	-4.17	-4.17	1.63	1.47	-0.84	0.69	0.43
4	-0.01	-0.63	0.29	0.18	-0.38	0.56	0.40
5	-0.13	-0.13	1.14	0.85	0.21	0.24	0.18
6	0.04	-0.17	0.05	0.03	-0.02	0.58	0.38
7	0.15	0.15	0.12	0.10	-0.11	0.06	0.05
8	0.00	-0.04	0.03	0.03	0.01	0.25	0.17
9	-0.09	-0.09	0.13	0.10	0.05	0.02	0.01
10	-0.01	-0.01	0.05	0.03	0.00	0.05	0.03
11	-0.62	-0.62	0.02	0.01	0.00	0.03	0.02

Measured Data in D2L108

Integral; 3.8 Tesla (6000 A) at 25 mm radius

n	$bn(L)$	$bn(R)$	$an(L)$	$an(R)$	n	$bn(L)$	$bn(R)$	$an(L)$	$an(R)$
2	-0.09	0.40	0.13	-1.51	2	OK	OK	OK	OK
3	-0.83	-0.78	-1.44	-1.29	3	??	??	OK	OK
4	0.56	-0.03	-0.35	-0.49	4	??	??	OK	OK
5	-0.18	0.00	0.10	0.16	5	OK	OK	OK	OK
6	0.16	-0.10	-0.05	0.09	6	??	OK	OK	OK
7	0.15	0.15	-0.11	-0.07	7	OK	OK	OK	OK
8	0.02	0.00	0.06	0.07	8	OK	OK	OK	OK
9	-0.20	-0.17	0.03	0.03	9	OK	OK	OK	OK
10	-0.01	0.00	0.06	0.06	10	OK	OK	OK	OK
11	-0.65	-0.62	-0.01	0.01	11	??	OK	OK	OK

OK=Value between (mean- $\Delta-\sigma$) & (mean+ $\Delta+\sigma$)